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SERIES CIRCUITS

Series Circuits are the least complex of all electrical circuits regardless of the number of components in the circuit. This lesson will use Ohm's Law and Kirchhoff's Laws for understanding series circuit operation and problem solving. The characteristic of a series circuit is that, if one component burns out, the entire circuit ceases to operate. The importance of series circuits lies in the fact that all circuitry, no matter how complex, can be broken down into an equivalent series circuit.

A series circuit is a circuit in which there is only one path for current to flow. It is made up of components connected end-to-end. Basically there must be a source of voltage, and a path for current which has resistance.

The definition of a series circuit is: a circuit which has one path for current to flow. See the examples as shown in FIGURE 3.

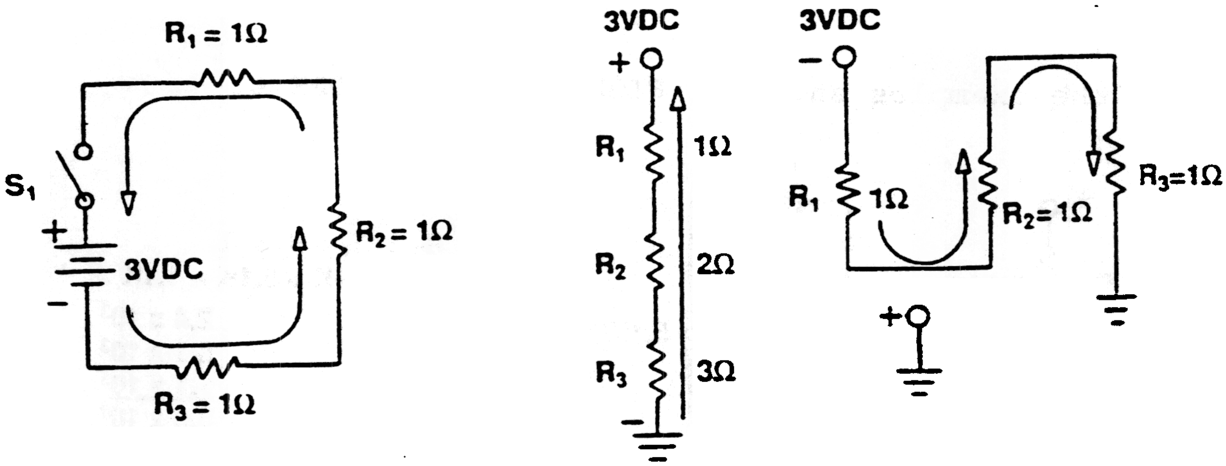


FIGURE 3 (SLIDE EP11AL-03)

It has been proven that resistors in series add.

When resistors are connected end to end, they are in series and may be added directly as shown in FIGURE 4, below.

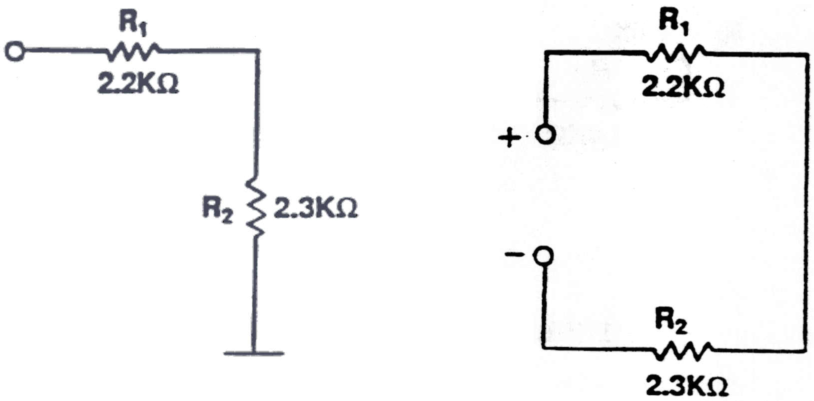


FIGURE 4 (SLIDE EP11AL-S04)

SERIES CIRCUITS

Total resistance is labeled R_T. Each resistor will be labeled R_1, R_2, R_3, etc. Then we may write a formula for adding resistors as follows:

$$R_T = R_1 + R_2 + R_3 \cdot \quad \cdot Rn$$

In FIGURE 4, circuit A,

$$R_T = R_1 + R_2$$

$$R_T = 2.2K + 2.3K$$

$$R_T = 4.5K$$

In FIGURE 4, circuit B, we have the same values drawn differently, but still in series, thus $R_T = 4.5K$

Study the examples shown in FIGURE 5 and FIGURE 6

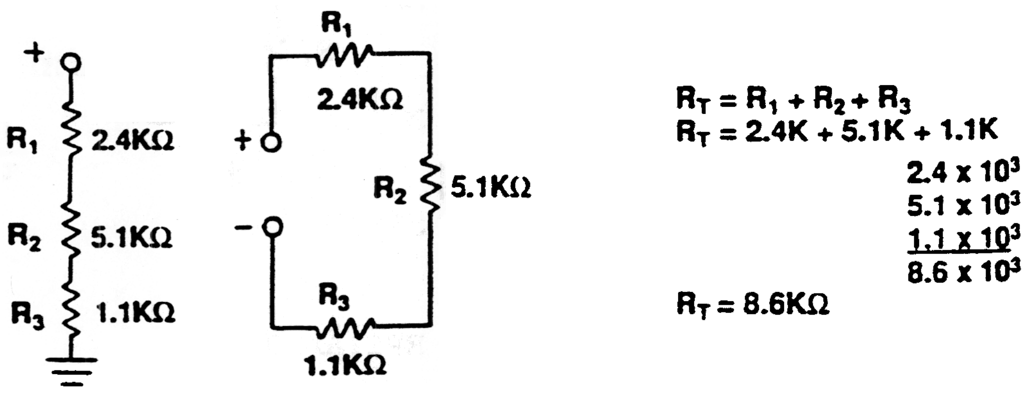


FIGURE 5 (SLIDE EP11AL-S05)

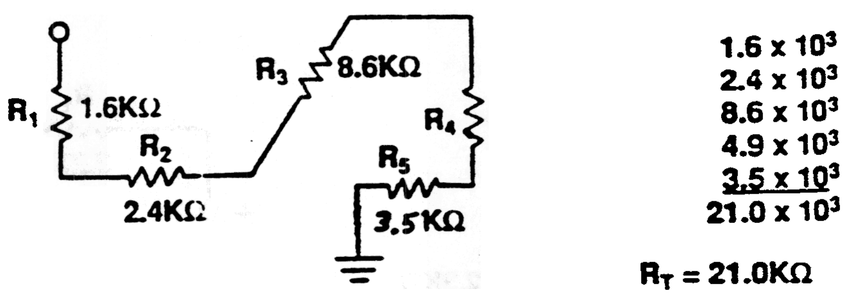


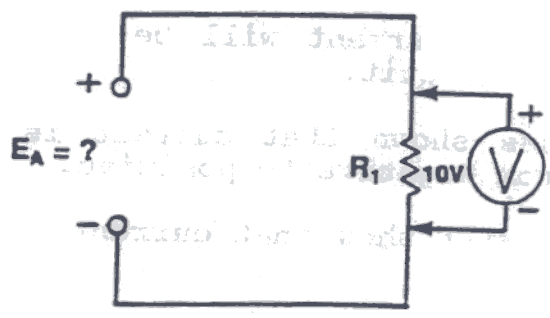
FIGURE 6 (SLIDE EP11AL-S06)

SERIES CIRCUITS

The voltage drops in a series circuit can be expressed by Kirchhoff's voltage law. The total voltage applied to a series circuit is equal to the sum of the individual voltage drops. This can be expressed in the following mathematical expression:

$$EA = E_{R1} + E_{R2} + E_{R3} + \ldots E_{RN}$$

In FIGURE 7 it may be shown how to calculate the voltage drop across a circuit containing only one resistor.



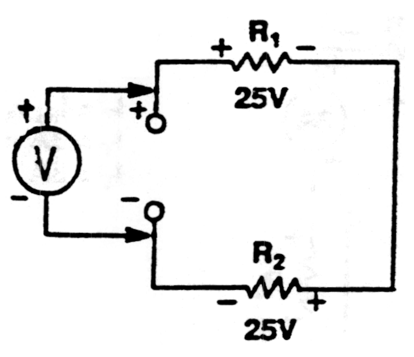
$E_A = E_{R1}$

$E_A = 10V$

FIGURE 7 (SLIDE EP11AL-S07)

If E_{R1} = 10V and $E_A = E_{R1}$, then E_A = 10V. This is according to Kirchhoff's Law.

In FIGURE 8, it may be shown how to determine the voltage drops and applied voltages in the circuit.



$E_A = E_{R1} + E_{R2}$
$E_A = 25V + 25V$
$E_A = 50V$

FIGURE 8 (SLIDE EP11AL-S08)

In FIGURE 8, $E_A = E_{R1} + E_{R2}$, where E_{R1} = 25V and E_{R2} = 25V, thus;

E_A = 25V + 25V

E_A = 50V. again this is an application of Kirchhoff's Law.

It may be noted that some problems may use E_T instead of E_A. In this case $E_T = E_A$, they are the same value.

SERIES CIRCUITS

Since the series circuit has only one path for current flow and only one voltage supply or source, it is possible to use Ohm's Law in conjunction with Kirchhoff's Law to calculate voltage drops.

As has been stated previously, a series circuit has only one path for current flow. This current will be labeled I_T, and may be expressed by Ohm's law as follows:

$$I_T = \frac{E_A}{R_T}$$

Where R_T may be one or more resistors.

It may be concluded that current will be the same in a series circuit at any point in the circuit.

Previous discussion has shown that current is the movement of electrons and they move from negative to positive.

FIGURES 9, 10, and 11 will show that current is the same at all points in a series circuit.

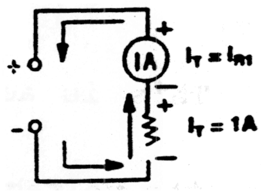


FIGURE 9 (SLIDE EP11AL-S09)

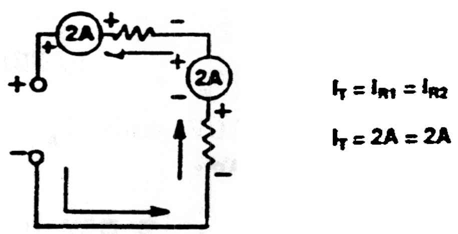


FIGURE 10 (SLIDE EP11AL-S10)

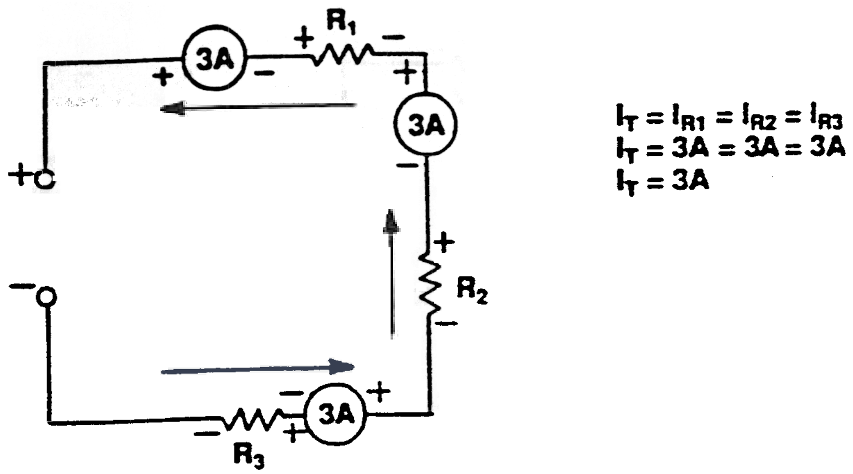


FIGURE 11 (SLIDE EP11AL-S11)

Now you know the why and how of the resistance, the current, and voltage, the unknowns of these values may be calculated using Ohm's Law.

It would be wise to always write the formula down before trying to complete the calculations.

SERIES CIRCUITS

The first step in calculating an unknown value is to determine what is the unknown.

In FIGURE 12, there is one resistor, R_1, and an applied voltage of 20V; and a path for current flow.

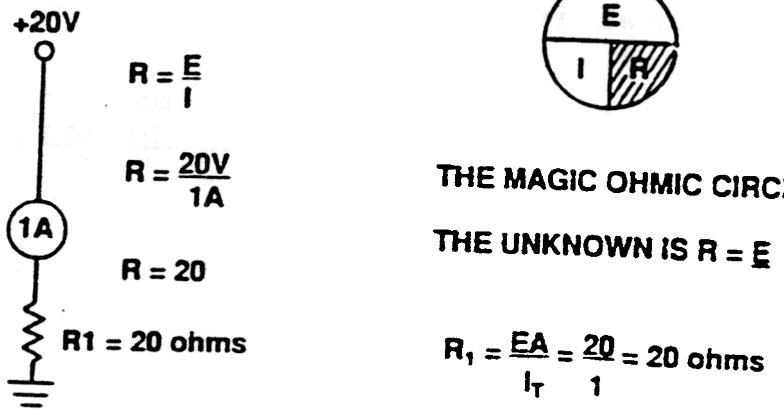


FIGURE 12 (SLIDE EP11AL-S12)

In FIGURE 13, it can be shown that the voltage drop across R_2 or E_{R2}, can be found two ways.

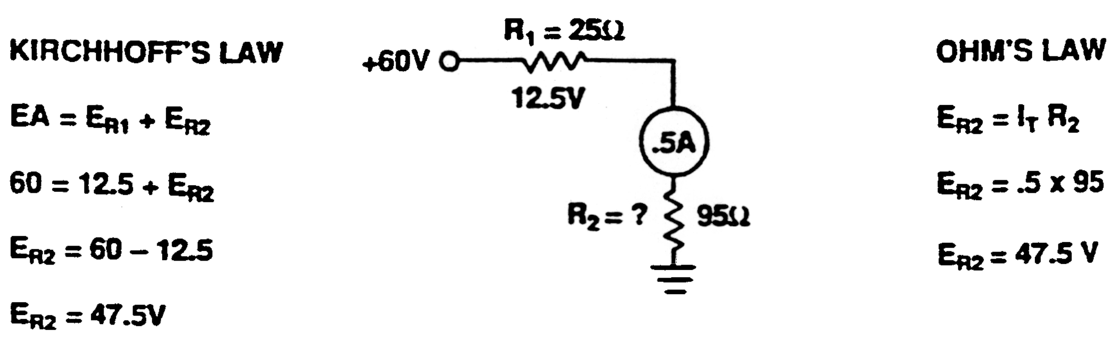


FIGURE 13 (SLIDE EP11AL-S13)

You have learned from previous studies that current, voltage and resistance are each affected by the other.

EXAMPLE:

E = I R, I and R, are both directly proportional to E.

$I = \frac{E}{R}$, I is directly proportional to E, I is inversely proportional to R.

$R = \frac{E}{I}$, R is directly proportional to E, R is inversely proportional to I

SERIES CIRCUITS

To summarize, a series circuit has only one path for current flow. This means that the current is the same at any point in the circuit.

Total resistance in a series circuit is obtained by adding the individual resistors.

Applied or total voltage is the sum of the individual voltage drops.

When measuring current and voltage, polarity must be observed. <u>When measuring current the circuit must be broken and the meter placed in series with the circuit</u>.